The Physiology of Digestion

An Essay

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by

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The term digestion may be said to include mastication, insalivation, deglutition, and the action of the stomach and small and large intestines, each of which functions is a step towards the conversion of crude alimentary material into a reparative juice, designed to renew the decaying tissues of the body.

Man is omnivorous, the food to supply his wants is obtained from the animal and vegetable kingdoms, and from these extensive sources every thing which tickles the palate is found upon his bill of fare. This is more especially the case in the temper-

ate latitude, where the varying seasons create a necessity for different kinds of food. The inhabitants of the cold countries where almost a perpetual winter reigns live principally upon animal food containing a large amount of fat, while those living in the warmer climates subsist mainly upon vegitable food.

It might be queried in this connection whether such a state of things would answer the requirements of the system in supplying material for the nourishing of the various tissues. Though this matter will be more fully explained hereafter it may be well here to suggest that

nature possesses a peculiar faculty of adapting herself to the circumstances under which she is placed, and though a mixed diet is more conducive to a healthy state of the organism, and to a certain extent essential, still it is found that those people who live almost beyond the limits of vegitable life thrive upon blubber and oil, and moreover those elements which are derive from the lighter vegitable food exist though in a limited extent in animal food.

The function of dugestion is performed in what is denominated the alimentary canal or track, beginning with the mouth and terminating within

the rectum. As we do not consider defecation the object of digestion but merely as a result we cannot agree with Professor Dunglison in including that function in the digestive process. As well might we include any of the excreting organs, the urinary apparatus, the lungs or the skin.

We have already said that mastication is the first step in digestion. It is performed by the teeth aided by the tongue and cheeks, which assist by placing and retaining the food in a situation to be acted upon by the teeth, which close upon it successively, completely mashing it and thereby allowing the saliva to penetrate the mass

Within the substance of the soft parts of the mouth, or of its walls are situated various conglomorate glands, each of which secrets a peculiar fluid.

The parotid glands are two in number, situated one upon each side immediately in advance of the ear, and each of which opens by a separate duct, called the duct of Steno, opposite the second superior molar tooth of its side. These glands furnish a clear, viscid fluid without taste or color, and of an alkaline reaction. its secretion is continuous but, like that of all the buckal glands, is augmented by the stimulus of food in contact, and it

is said also by the sight or even the thought of food which is known to have a luscious taste. This secretion constitutes about 7/8 of the bulk of the saliva —

The submaxillary glands situated also upon each side and at the angle of the lower jaw empty through the ducts of Wharton, a fluid like the former colorless, tasteless and inodorous, though but slightly acid and less strongly alkaline.

The sublingual glands, located beneath the tongue, being nearer the surface open open by several mouths, which do not like the former unite in

a common excretory duct.

In addition to the above there is also a lingual gland which is found as its name indicates in the tongue, and which also supplies its quota to the saliva.

These fluids united and combined with a fourth from the mucus lining of the ~~xxxxxxx~~ mouth which is very frothy and tenacious, and in its sensible properties similar to the foregoing constitute the saliva.

The chemical reaction of saliva has been much discussed by Physiologists. It is contented by Messrs Tiedmann and Gmelin that it is invaria-

-bly alkaline, in a healthy condition of the stomach. M. Donne coincided with the above view, and further considered acidity of the saliva as a diagnostic symptom of gastritis, while Mr Laycock, who from his extensive observations, having performed upwards of five hundred tests upon saliva, would appear to be worthy of consideration, gives the following as the results of his researches — 1st. The saliva may be acid without apparent disease of the stomach. 2d It is alkaline during different degrees of gastric derangement as indicated by the tongue. 3d. It may be acid, alkaline and neutral while the

gastric phenomena are the same, and consequently acidity of the saliva is not a diagnostic mark of gastric derangement, and lastly, in general, it is alkaline in the morning and acid in the evening.

It is evident from the above observations that the author includes as saliva the mixture of the true saliva with certain products of the stomach. In considering the character of the saliva or of any other secretion it is necessary that the attention be directed to the pure unadulterated secretion, and not to a compound, and then advance the result as that of

stances in health, for instance, it is greater immediately after taking food.

Analyses of saliva show it to be composed as follows, in 1000 parts are found 995 parts of water, and 5 parts only of solid constituent. In the latter Berzelius found ptyalin, the organic principle, to be 2,9, mucus 1.4, Chlorides of potassium and sodium 1.7, Lactate of soda and animal matter .9, Soda 2, but he gives 992.3 parts of water leaving 7.8 as the amount of solid constituent.

Numerous epithelial scales are observed floating about in the saliva, which are supplied

by the buchal mucus.

The quantity of saliva secreted daily is estimated at about three pounds, varying in amount in different individuals and in under different circumstances ~~xxx~~ the same.

Probably the most important use of the saliva is to soften the food and to facilitate mastication, and render the food more susceptible to the action of the other juices. The parotid fluid is supposed to be the principal agent however in the above process, and the submaxillary fluid being more viscid and consistent is thought to envelope the alimentary bolus

an investigation upon a single secretion. This has undoubtedly given rise to much unnecessary discussion and is the principal cause of the vast number of theories which so much embarrass the student of Physiology. We are not unaware that many obstacles oppose the procurement of pure unmixed saliva, still that does not wholly justify experiments for the confusion they cause in the science - Tiedmann and Gmelin have examined saliva and give the result. Mr Laycock has examined a mixture of saliva with gastric juice and bile &c and begs

leave to differ, what an attitude for men of science, especially when they allow the gastric juice to be an acid and therefore will deprive the saliva of its alkaline properties. But it is healthy digestion that we are considering and we will therefore confine our remarks to normal saliva, for what may be the character of saliva mixed with the product of a deranged stomach is not pertinent to our subject.

It is now almost universally conceded that saliva is alkaline in its reaction and such we believe to be the case, although its degree of alkalinity varies under different circum-

and by lubricating its whole surface much facilitate the act of deglutition, a further function of the saliva is to convert boiled starch into grape sugar or dextrin. This is probably owing to its alkaline properties, as this process is arrested by the acid of the gastric juice.

Deglutition immediately follows mastication and insalivation, and is divided into three steps, the first is a voluntary motion and is effected by forcing the tongue against the roof of the mouth, the pressure commencing anteriorly and carrying the bolus in advance, is gradually forced backward and

deposited in the pharynx. The bolus passing backward carries the uvula before it and preping it against the opening of the posterior nares prevents the passage of any substance in that direction.

The second step conveys the ball but a short distance and is performed by a sort of convulsive movement and very suddenly, in order to avert any serious consequence which might arise from keeping the air passage obstructed for any appreciable length of time. In the third stage the pharynx contracts forcing the bolus into the oesophagus after which it proceeds quite slowly

It might be thought that its own weight would be sufficient to impel the bolus downward to the stomach, but though this must have its influence in that direction it is not left to that alone, for it will readily occur to the mind that circumstances might arise at times causing much embarrassment if there were no active power which carried the food into the stomach.

The muscular fibres of the oesophagus are arranged in circular and longitudinal directions, the former encircle the tube along its entire length and the fibres immediately before the advancing bolus are

relaxed thus dilating the tube, and those encircling and those immediately behind contract upon it, while the longitudinal fibres by successive contractions and relaxations greatly assist the operation. Arriving at the cardiac extremety the circular fibres contract and refuse to allow the bolus to pass, but it partially opens permitting a small portion to pass at a time until all is admitted. Now in the cavity of the stomach it is directed to the left end and winding around the curve is continued onward past the pylorus, and upward along the lesser curvature where it is lost in the mass, the

general direction of which is as that above described.

In order to understand the action of the stomach it is necessary to know something of its structure.

The stomach is simply a dilatation of the digestive tube in which the food is received and delayed for a greater or less length of time dependent upon its digestibility in a great measure. It is delayed here in order to undergo changes preparatory for absorption.

The stomach is situated in the left hypochondriac and epigastric regions, immediately beneath the diaphragm and liver, and

anteriorly it is in contact by its outermost or peritoneal coat with the abdominal walls. It approaches a conical form being curved near its centre, its base is directed toward the left and is continuous with the oesophagus which opens into it from above its apex is directed toward the right and is continuous with the duodenum or the beginning of the intestines. the longer curvature is downward and the lesser superiorly.

This viscus is made up of three distinct coats, a serous, muscular and mucus. the first being also the external is a reflection of the peritoneal membrane

which in front is thrown into a fold, which forms a sort of apron to protect the intestines. it will thus be seen that when the stomach is distended this fold is drawn up and the stomach enters between its two layers. The next is the middle or muscular coat, and is composed of three sets of fibres, disposed longitudinally, transversely and obliquely. the longitudinal set is continuous with those of the oesophagus and embrace the whole organ, the transverse or circular set do not extend completely around the organ but leave a space upon its superior aspect over which they do not pass. the oblique are

scattered and irregular in their distribution and found only upon its splenic extremety.

The inner or mucus coat is also composed of three layers the vascular, areolar and epithelial, the vascular is much the thickest and as its name indicates is supplied with a large amount of blood, the areolar or middle is called also the basement membrane, The entire length of the alimentary canal is lined by this mucus membrane which, independent of the glandular secretions, is lubricated by a secretion from the muciparous follicles which are found in vast numbers opening upon its surface

"The gastric juice perhaps plays the most prominent part in digestion of all the things we have to deal with, and besides being of great interest to the Physiologist it possesses also great practical importance to the practicioner of medicine for in a great number of the diseases which he is called to treat this secretion will be found deranged, and from the extensive sympathy which exists with the stomach its derangement gives rise to innumerable pains, aches and ailings.

The glands or follicles which furnish this fluid are simply single tubes in the mucus membrane extending down

into the basement membrane, and are lined for the superficial third of their course by the epithelial layer; these follicles pour out little cells (according to Beaumont who witnessed the act on the stomach of an individual who had a gastric fistula) upon the surface of the stomach containing a fluid, and the wall of this cell is ruptured upon entering the stomach and allows the fluid to escape. This fluid is the gastric juice, but unfortunately it exists only in imagination, that upon which experiments are instituted is necessarily mixed with the ingesta or more or less extraneous material

The gastric juice when obtained comparatively pure is a transparent fluid, inodorous, saltish, very perceptibly acid, and viscid. It is diffusible in wine and spirits, effervesces on alkalies, and is an effectual solvent of nitrogenised food, it coagulates albumen, and is a powerful antiseptic.

The books give a large number of analyses by different Physiologists which are as uniform as can be expected. It is sufficient here perhaps to present but one, and that is the average according to Prof. Dunglison of those experiments performed by Schmidt. It is as follows. Water 99.44, solid residue .56, ferments .32,

inorganic constituents .24, the latter composed of chlorhydric acid .02, chloride of potassium .06, chloride of sodium .15, chloride of calcium .006, phosphate of iron, magnesia and lime .013,

Heretofore there has been some contraiety of opinion touching the reaction of the gastric juice, but few if any are to be found now who do not admit that in its normal condition it is invariably acid, therefore we will not consume time by further remarks upon this point.

What is the acid of the gastric juice? Upon this question authorities are nearly equally divided between hydrochloric and lactic

acid. Professor Dunglison is of opinion the former predominates while Lehmann contends that lactic acid is most abundant. The former is sustained by the views of Blondlot and Leibig who believe that the lactic acid observed in the stomach is the result of the action of saliva upon starch or sugar, while the opinion of Lehmann is supported by that of Prout and we believe Bidder and Schmidt.

Beside the foregoing several other acids are found at times in this fluid, among them the most prominent are hydrofluoric, acetic, butyric and metacetonic acids. The salts

require no further consideration.

The organic constituent of gastric juice has received the name of pepsin, it is also known by the name of ferment. this and the acid are the active principles of the gastric juice.

It would be well perhaps in this connection to consider briefly the varieties of food which are employed. this may first be divided into nitrogenous, non-nitrogenous in the organic kingdom, and the mineral the latter including water and various salts. Nitrogenous food is obtained as was before remarked from both animal and vegetable food but in a more con-

centrated state in the latter especially in the muscular structure. It is therefore that laboring men, whose muscular tissues undergo a more rapid disintegration than those of sedentary individuals, require a greater supply of animal food and it has been proved by experiments that dogs kept upon sugar alone, which does not contain nitrogen, will die generally in from 30 to 35 days. The above practical experiments were performed by Magendie he also instituted other similar experiments in which he employed, instead of sugar as before, olive oil and distilled water, the result was similar to the for-

going. He also tried the same experiments with gum arabic and butter, at all times using non nitrogenous food. Professor Dunglison in remarking upon these cases says we have no proof that the animals died from being deprived of nitrogen. we see no difficulty in concluding with the celebrated experimenter that the dogs did die from being deprived, it is certain that they were so deprived and that they died, and that in a very uniform length of time and it does not appear that violence or any other cause save that attributed was the cause of their death. Suppose that instead of withholding nitrogen a-

done the animals had been deprived of nourishment altogether and in due time they succumbed, what is the inference, is it not obvious and irresistible that they died for want of food? We would like to know what, in the opinion of Professor D. was the cause of their death.

"Further experiments instituted by Magendie satisfied him that animals could not be sustained by a nitrogenous diet alone, but that they would die from starvation from which Professor D. argues that he has descended from his former position. It does not follow that because an individual denies one extreme he must rush immediately into the opposite, that

because dogs are not sustained by an exclusively nitrogenous diet therefore they must be by an exclusively non-nitrogenous ones the truth lies between the two extreme and there we think is the position of Magendie-

Having seen what are the effects of restricting the diet of a dog we can reason from analogy that a similar effect would arise in the case of a human subject and it is a matter of common observation that individuals when deprived of certain kinds of food show it in peculiar forms of disease. Only last Saturday five persons were received into the Pennsylvania Hospital

who had lately returned from a long voyage at sea who were suffering from scurvy. This disease undoubtedly arose frm want of fresh vegitable food.

We have already described the functions of the saliva. Besides softening the food we found that it also assisted in converting starch into grape sugar.

The gastric juice has a very important office to perform, that of converting albumen into albumenose. The water like that of the saliva is necessary to moisty the material and thereby facilitate the action of the two active principles, the acid and the pepsin. It is the office of the former to dissolve

the food and prepare it for the action of the latter which is that of converting nitrogenized food into albumenose. The acid of this juice also arrests the transformation of starch into dextrin or grape sugar. Oleaginous food undergoes no essential change in the stomach, except that its cell walls being albumenous are subject to the action of the gastric juice, which gives it a milky appearance.

"After due preparation the chyme is passed through the pylorus into the duodenum. This organ is the commencement of the small intestine and is situated immediately below the stomach. Two important fluids are found emptying into

this organ, the bile and the pancreatic juice. The bile is formed in the parenchyma of the liver, it is of a dark, golden brown color, viscid and slightly bitter, and upon analysis is found to be composed as follows. In one hundred parts of bile are found 88. parts of water, glycocholate of soda and tauocholate of soda 10 parts, oleate, stearate and cholesterine 1.42, chloride of sodium, phosphate of lime, phosphate of soda, phosphate of magnesia, carbonate of soda and potassa 1.24, and mucus of gall bladder 1.34.

The function of the bile is a subject upon which there has been much discussion. In the first place it is secreted from

the circulation because it can be of no service there, but would be actually deleterious in its effects. Secondly, the water contained in the bile serves a good purpose in the intestines by molifying the faecal matters, facilitating their passage along the canal and ultimate expulsion. In answer to the first of these it may be argued that as the bile is taken from the portal blood, or more correctly is manufactured in the liver from the portal blood which is direct from the absorbents and not having passed through capillaries this would be a work of supererrogation, as nature could have prevented the

admission into the blood of these deleterious materials. It is necessary to attribute to the bile some function commensurate with the intricacy of the apparatus by which it is eliminated, and that of softening the faecal matter, would not appear to be sufficient for that purpose; and if it were what can be said of the uses of the solid constituents. One of the first who directed their attention to this subject was Boerhaave. He was of opinion that the alkaline principles of the bile tended to neutralize the acid of the chyme, and thereby served some beneficial purpose. Lehmann has put this theory into a more tangible form

by remarking that mixed with the chyme the alkali of the bile exchanges the weak acid with which it is combined for the much stronger which occurs in the chyme. The bile also undoubtedly exercises an antiseptic influence upon the chyme. Bidder & Schmidt satisfied their minds that the digestion of albuminous and amylaceous material is not in any manner disturbed by cutting off the supply of bile while that of the oleaginous is almost completely suspended. After enumerating the various theories and experiments upon bile Lehmann concludes with the

assertion, that the participation of bile in the digestive process must therefore be considered as settled beyond a doubt, but its mode of action still remains unsettled.

The pancreas is situated below the stomach across the epigastric region from the right to the left kidney, the two extremities projecting into the lumbar regions and is about eight inches long. It has been found that the pancreatic juice of a dog amounts to 14½ grains per hour, while that of man is supposed to be considerably more. It is a colorless, limpid slightly tenacious fluid without taste or smell, and hav-

ing an alkaline reaction.

One hundred parts of pancreatic fluid are found to be composed of water 90 parts, organic matters 9 parts, and various salts of which chloride of sodium is the principal. The organic principle of this fluid is a substance much resembling albumen.

Until within a few years the pancreatic juice has been but imperfectly understood, but the investigations of Bidder and Schmidt, Bernard and French have thrown much light upon its character and functions. In these it closely resembles saliva, and is therefore frequently called the pancreatic saliva. The metamorphosis

of amylaceous material into grape sugar which was begun by the saliva is resumed and carried on with more energy by this fluid, according to Bidder and Schmidt its action is confined within the upper half of the small intestine. Bernard was convinced that by the action of the pancreatic juice the oleaginous material were changed in a manner essential to prepare it for absorption, but Bidder and Schmidt as well as Bernard by numerous carefully conducted experiments could discover nothing to warrant such a belief, the latter observed after making a section of the small intestine some distance below the entrance of Wirsung's duct

and injecting olive oil into each of the open extremities, which were then tied, that the lacteals proceeding from the lower portion though somewhat injected, were not to so great a degree as those above the section,

The experement of Bernard was made by simply cutting off the supply of pancreatic fluid while Bidder and Schmidt cut off also that of the bile, and we fail to see how this can invalidate the results. It will also be observed that this freedom taken by them is consistent with their view regarding the function of the bile.

We have now remaining for consideration one more product

the intestinal juice, This is in a great degree secreted by the glands of Lieberkühn which occur in the large and small intestines, The glands of Peyer also furnish a small part of this fluid. It is described by Frerich as a glassy, transparent colorless and tenacious liquid with a strong alkaline reaction. Lehmann had the good fortune to fall in with an individual into whose intestines there existed several fistulous openings, and was allowed to extract therefrom intestinal juice for examination. His remarks are worthy of repetition. The morphological elements he observes found in the intestinal juice are granular cells found in greater or less abun-

dance, cell nuclei here and there a little fat and cylindrical epithelium very abundant. He found a fraction over two per cent of solid constituents. It is conclusively proved by numerous experiments that the intestinal juice possesses the power of digesting starch and nitrogenous material, and probably act upon those parts which have escaped the action of the other digestive fluids.

We have thus imperfectly delineated the physiology of digestion. We have found many points hypothetical and uncertain and therefore clothed with interest. An immense amount of labor has been expended upon

this branch of physiology, and rays of light are beginning to penetrate the darkest points, and through the continued efforts of zealous investigators a light will ere long be placed in the hands of the physician which will enable him to alleviate much suffering and which, in the treatment of disease, will be a grand auxiliary to that great law of nature, *similia similibus curantur*.